

4

ON THE
MINUTE STRUCTURE
OF A
PECULIAR COMBUSTIBLE MINERAL
FROM THE
COAL-MEASURES OF TORBANE-HILL,
NEAR
Bathgate, Linlithgowshire.

By JOHN QUEKETT,
PROFESSOR OF HISTOLOGY TO THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

[*Reprinted from the QUARTERLY JOURNAL of MICROSCOPICAL SCIENCE.*]



PRESENTED
BY THE
AUTHOR.

LONDON:
SAMUEL HIGHLEY, 32, FLEET STREET.
1854.

LONDON :

PRINTED BY W. CLOWES AND SONS, STAMFORD STREET
AND CHARING CROSS.

On the MINUTE STRUCTURE of a peculiar COMBUSTIBLE MINERAL, from the Coal Measures of TORBANE-HILL, near BATHGATE, LINLITHGOWSHIRE, known in Commerce as BOGHEAD CANNEL COAL. By JOHN QUEKETT, Professor of Histology to the Royal College of Surgeons of England.

THE substance in question has lately excited the greatest interest in the scientific world; and a trial, second to few in importance, has recently taken place in Edinburgh, having for its object the determination whether the Torbane-hill mineral should be called a coal or not, and whether it should be included in the missive of agreement for a lease, and let as coal. Those of my hearers who may wish for a particular account of the matter in dispute, and a statement of the facts brought forward, both by the pursuer and defender, or, with us in England, plaintiff and defendant, I would beg to refer to Mr. A. W. Lyell's Report of the trial, published by Messrs. Bell and Bradfute of Edinburgh.

Upon this trial no less than seventy-eight witnesses were examined—thirty-three for the plaintiff, and forty-five for the defendant. They might be classified as geologists, mineralogists, chemists, microscopists, and practical engineers, such as gas managers, miners, &c.

With four of these classes of scientific witnesses I have no immediate concern, and will, therefore, leave them to settle their own differences; but not so with the microscopists, with many of whom my opinions are entirely at variance.

In order that you may all fairly understand the nature of this question, as far as the microscopical observers are concerned, I will, in the first place, give you a detailed account of the minute structure of the Mineral itself. Secondly, I will give a brief description of the minute structure of Coal. Thirdly, I will lay before you the whole of the evidence given by the microscopists on the part of the pursuer as well as the defender; and lastly, make a few remarks upon the conflicting testimony of some of the witnesses.

I wish that the matter had fallen into abler hands than mine; but having been intimately acquainted with the mineral in dispute for some time past, and as two of the oldest members of this society, Mr. Bowerbank and myself, have had their competency called in question, and have been represented by the Judge as no botanists, and, therefore, "are not, as I understand, conversant or skilful in fossil plants," and the society itself not having escaped his ridicule, the jury being

informed that the Microscopical Society of London is "a learned body, who make it their object to pry into all things," I cannot be silent; but I would have you keep in mind that my sole motive in now appearing before you, is, the cause of truth, and in this cause I come forward fearlessly, but honestly, to state that the Torbane-hill mineral is not, microscopically speaking, a Coal; that it is not like any of the combustible substances used in this country as Coal; and that, although possessing some of the properties of Coal, it is, notwithstanding, a mineral *sui generis*, having a basis of clay which is strongly impregnated with a peculiar combustible principle, and that when plants are found in it, they are accidental, and have no more been concerned in the formation of the mineral than has a fossil bone in that of the rock in which it may be imbedded.

1. *External characters of the Mineral.*—Of these you will have a good general idea from the specimens on the table before you. It frequently occurs in seams of some considerable thickness, and always in the neighbourhood of coal, sometimes in immediate contiguity with it, but at other times, according to Mr. Ansted, separated from it by a layer of fire-clay. The colour is generally a dark brown or black, without lustre, but varies according to its position in the seam; its specific gravity is $1\frac{2}{10}$ or $1\frac{3}{10}$, water being as 1. When scratched with a knife it exhibits a brown streak, in which particular it is said to differ from all the known coals with one or two exceptions. It is tough and not so brittle, but that very thin sections may be made of it, and when struck with a hammer, it emits a dull sound; the remains of plants, especially *Stigmaria*, are of constant occurrence, and can be distinguished by the naked eye without difficulty.

2. *Characters exhibited under the Microscope.*—When a small chipping or fragment, about half an inch square, is examined as an opaque object under a power of 40 or 50 diameters, it will be found to consist of masses of a yellow material, some being of irregular figure, others more or less rounded, imbedded in a granular matrix, varying in colour from a yellowish-brown, almost to black. The whole of the mineral appears to be composed of granules of various sizes, and although the part which has been termed the matrix is black, this also will become brown if the surface be scraped. The scraping can readily be done under the microscope whilst the fragment is being inspected; and, curiously enough, both the surface of the mineral, and the minute particles scraped off, assume a light-brown colour. Portions of plants imbedded in the mineral can, by the process of scraping, be readily distinguished from the impressions of plants; the former are

always black and do not alter in colour, whereas the latter become brown, the same as other parts of the mineral.

3. *Characters exhibited by sections under the Microscope.*—There appear to be two principal varieties of this mineral, one of a yellowish-brown colour, the other nearly black, these differences, however, are chiefly dependent upon the position the particular fragment selected for section occupied in the block. When the first variety is reduced sufficiently thin to be transparent, which can be done without much difficulty, it will be seen to consist of a tolerably uniform, yellow mass, whilst the darker variety is either of a rich brown, or of a pale-yellow colour, minutely spotted with black granules. When the first or yellow variety is examined with a power of 50 or 100 diameters, it exhibits an appearance of being made up of a mass of transparent rounded particles or spherules of a rich yellow or amber colour, varying in size from the $\frac{1}{100}$ th to the $\frac{1}{10}$ th of an inch (as shown in Plate I., fig. 1), whilst the darker variety (fig. 2) is composed of two essential elements, one in the form of the transparent rounded particles, the other minutely granular, but black and opaque, and occupying the spaces between the yellow particles. In the first variety of this mineral, or that which is of a yellowish-brown colour in section, the yellow particles above alluded to are so very abundant, that they appear almost to make up the entire mass, whilst the dark granular element is small in quantity. In the second, or dark variety, the strictly granular opaque element is much more abundant; it sometimes occurs in large patches, having none of the yellow particles with it, but more frequently it is found in the form of a coating to the particles themselves. When the yellow particles are of large size, they always exhibit more or less of a radiated structure internally: this appearance, which is well represented in figs. 1 and 2, very much resembles that of a radiated fracture, or a species of crystallization. I shall now, for the sake of distinction, call all these yellow particles, or spherules, the bitumenoid or combustible portion of the substance, and the dark, granular part, I shall consider as the strictly mineral, or earthy ingredient.

In some specimens there is a tolerable regularity in the size of the yellow particles, and in the disposition of the black mineral ingredient around them, so much so that an unpractised eye might, at first sight, consider its structure to be cellular: that such mistakes have actually been made you will very soon have an opportunity of learning.

Having told you what is the usual structure of the substance in question, I must beg you to understand that it matters little

in what direction the sections are taken ; whether cut vertically, horizontally, or obliquely, there is no perceptible difference in the structure, and I say it without fear of contradiction, that no one, however skilled in microscopical observation could, from the inspection of a single specimen, state the direction in which the section had been made. Such is not the case with coal, as will hereafter be shown ; a single inspection is sufficient to enable a practised microscopist to determine the actual direction of the section, whether transverse or longitudinal.

Examination of portions of the Mineral having Plants imbedded in their substance.—I have already stated that plants and the impressions of plants are not uncommon in this mineral ; of these I have made numerous sections and chip-pings, and most instructive they all are. The plants appear to be principally *Stigmariæ*, and exhibit more or less of the three tissues known to botanists as the cellular, the woody, and the vascular ; and should one or more of these be present in any section, the minutest fragment even of a cell or vessel can be readily recognised by a practised observer ; they, as it were, stand out boldly from the mineral matter in which they are imbedded, and (as shown in figs. 3 and 4) can be distinguished in all cases by their rich brown colour ; but such plants I not only consider as extraneous and not forming the bulk of the mineral, but such plants my investigations lead me to conclude rarely if ever form coal ; at all events no coal that I have yet examined has ever exhibited the least trace of being made up of such plants as are so commonly seen imbedded in this mineral. Even the coal lying upon this mineral, and running through it in every possible direction, is composed principally of woody tissue, and not of plants such as these.

Examination of sections of the Mineral having Coal in juxtaposition.—The first specimen of this kind which I had the opportunity of examining was brought by Mr. Bowerbank himself from one of the Torbane-hill pits. From this specimen several sections were taken ; one of them slightly magnified, is represented in Plate III., fig. 1. I regret I cannot show you the specimen itself, it being lodged in the Court of Session, in Edinburgh ; but I have been favoured with a somewhat similar one through the kindness of Mr. Gratton. As the block lay in the pit, the coal was situated below the mineral in the position I now hold it, and you will readily be able to distinguish the one from the other by the naked eye ; but when viewed with a power of at least 50 diameters (as shown in Plate I., fig. 5), the smallest fragment of the coal that may happen to be mixed up with the mineral may be

readily traced; even a part so minute as a single woody fibre can easily be recognised.

In some specimens, the line of demarcation between the coal and the mineral is not very decided, owing to the coal and the plants found in connexion with it being so intimately blended; in all such cases recourse should be had to the streak, as the best guide to distinguish them. In every part of the block containing coal and coal plants, the streak is black; but in the smallest portions of the mineral it is brown. It is a curious fact, however, that in the specimen now before you, three kinds of structure are visible to the naked eye: 1st, true coal; 2nd, a mixture of coal with a few coal plants, principally *Stigmariæ*; 3rd, the mineral. When sections are made through the block in two directions at right angles to each other, the coal and the mixture of coal and plants will exhibit a structure corresponding with longitudinal and transverse sections of wood, but the mineral is the same in both sections. The yellow particles occupy all the interstices in the coal, and vary in shape, according to the spaces they have to fill (as shown in fig. 5); but whether they be elongated or of circular figure, more or less of the radiated structure is present in every particle. In such sections the vegetable tissues may be distinguished from the earthy ingredient by their rich brown colour.

Examination of the Powder.—When the Torbane-hill mineral is reduced to powder, and examined either in water or in Canada balsam, the combustible and incombustible portions can be well seen; the one occurring in the form of the yellow or amber coloured particles before noticed, and constituting full two-thirds of the mass (as shown in Plate I., fig. 6), whilst the remainder is made up of minute opaque granules, having occasionally amongst them some which are quite transparent, and probably siliceous.

Characters of the so-called Coke and of the Ash.—Three portions of the coke of the Torbane-hill mineral, each about 4 inches square, obtained from a gas-retort by Mr. Gratton, were of a greyish colour, and when scraped became perfectly black. The remains of plants were very visible throughout the substance of each, and were even more distinctly seen in the specimens of coke than in the mineral itself before being subjected to heat, for every part, however minute, had assumed a silvery appearance. When a flat piece of the coke, about half an inch square, is examined as an opaque object under a power of 50 or 100 diameters, it presents a peculiar sponge-like structure; and when contrasted with a portion of the mineral, it will be noticed that all the yellow particles

have disappeared, and a pitted appearance is produced, the pits being nothing more than the cavities in which the yellow particles were lodged, and the walls of the pits being the granular earthy ingredient which at one time surrounded the yellow particles. When small fragments of the coke are scraped off and subjected to a power of 250 diameters, none of the yellow combustible principle is present, the entire bulk being made up of dark granular masses. If the mineral be burnt in an open fire, the ash will be nearly white; and when examined microscopically, no trace of the yellow combustible matter will be seen, and the granules (as shown in fig. 7) will be very minute, and of a light colour. These appearances will be constant, if care be taken to select a part of the mineral in which no traces of plants are visible to the naked eye; but if portions of plants be present, they will be readily recognised by their woody and vascular tissues. The principal distinction, therefore, between the coke of the gas-works and the ash is, that in the former the granules are larger and blacker than they are in the latter.

From these and numerous other observations, I conclude that the mineral in question is a clayey substance, impregnated with a combustible material occurring in the form of rounded particles of a rich yellow or amber colour, but, whether these particles be bituminous or not the chemists must decide.

What I have already stated refers exclusively to the Torbane-hill mineral, and no mention has yet been made of the structure of coal. Under this head I could enter into a detailed account of most of the well-known varieties of British coal, my knowledge of which has been principally derived from a careful investigation of sections made by myself and by my friend Dr. James Adams, of Glasgow; and I am happy in having this opportunity of bearing testimony to the correctness of the observations of Dr. Adams, upon which his opinions had been formed prior to my having the pleasure of his acquaintance. Were I now to describe these, I fear you would be kept here many hours; but it is the intention of Dr. Adams and myself, at no very distant period, to read a paper on the minute structure of the principal kinds of British coal, before the Geological Society, as we deem *that* the most fitting place for such a subject. For our present purpose, therefore, it will be merely necessary for me to give, in as concise a manner as possible, the results of the investigations of Dr. Adams and myself on this point; but I would have you understand that although I give you a general description of the structure of coal, I have with me the specimens from which

you will be enabled to judge for yourselves whether my statements be correct. I am fully aware that the prevalent opinion with geologists and botanists is, that coal is made up of fossilized vegetable matter, and that this vegetable matter may consist of stigmariæ, ferns, mosses, &c.; in short, of a great variety of vegetable substances. My investigations, however, lead me to believe that the basis of coal is essentially a peculiar kind of wood, and that when ferns, stigmariæ, lepidodendra, and other plants occur in coal or its neighbourhood, they should be considered foreign to the coal, as these plants, before noticed, are to the Torbane-hill mineral. However contrary this may be to our preconceived notions, yet all the sections on the table before you, on a careful examination by an unprejudiced observer, can lead to no other conclusion. I believe that there are in this room at the present time more sections of coal than any private individual has ever yet produced before a scientific assembly, and it is from these specimens, and from the study of these alone, that I am warranted in making this assertion. The botanist will remember that most of the plants generally considered as forming coal, are such as on section will exhibit more or less of the cellular, woody, and vascular tissue: now it is a remarkable fact, that most of the plants visible to the naked eye in the Torbane-hill mineral, as well as those lying in the strata above and below coal in general, are those which may contain spiral or other vessels; but, judging from all the sections of coal now before you, as well as chippings of others too numerous to mention, I am forced to the conclusion that such plants rarely if ever form coal, the basis of coal being essentially *wood*, of what kind, however, I will not at the present stage of the inquiry venture to mention, but I will state thus far, that it approaches more nearly to that of the Coniferæ than any other wood; because in the Coniferæ, as we know them in this country, there are few if any vessels or ducts in the woody part of the trunk, but occasionally cellular tissue in what are called the turpentine vessels, the entire bulk being woody fibre. Such is the case in coal. In all the sections that I have examined of undoubted coal, I have as yet found no trace of a spiral vessel or a dotted duct, but in one or two instances where the woody structure has been very evident, as shown in Plate III., fig. 3, the fibres were evidently dotted.

External Appearances of Coal.—These must be so well known to most of you, that I need not dwell further upon them than to particularise one or two kinds which approach nearest to the Torbane-hill mineral in general appearance. The most remarkable of these is from Methil, in Fifeshire, and known as the *Brown Methil*. So peculiar is it, that

when scratched with a knife, the streak is brownish-black in colour, somewhat resembling that of the mineral. There is also another variety of coal, termed the *Black Methil*, but in this the streak is black, as in all other coals. Yet the microscopic characters of both these varieties are very similar, and differ in no respect from coals generally. A curious fact, however, I learnt from the chemists in Edinburgh, that the composition of the Brown Methil came nearer to that of the Torbane-hill mineral than any of the other known coals did; a fact which is borne out by the similarity in their external appearance.

Examination of Coal by the Microscope.—If a small cubical block of any kind of coal be examined under a power of 50 diameters, four of its six sides will exhibit more or less of a fibrous structure, precisely like that of wood; the other two sides, if perfectly flat, will appear bright and polished, and show very little structure: these correspond to the transverse sections of wood. Treat the Torbane-hill mineral in the same way, and how very different are the results! Nearly the same structure will be found on all its sides, but in none is there the least trace of a fibrous arrangement.

Examination of Sections of Coal by the Microscope.—If a section of any well-known coal, cannel or otherwise, be reduced sufficiently thin to be transparent, a work sometimes of considerable labour and difficulty, it will be found to exhibit one of two structures, according to the direction in which the section has been made. These, for the sake of distinction, may be called the cellular and the fibrous; the first corresponding with a horizontal section, the second with a vertical section, of wood. If it so happen that a section taken at random from any specimen of coal should exhibit one of these structures above named, by cutting at right angles, the other will be found. Thus, for instance, if the first section should correspond to a horizontal section of wood, the cut at right angles to it will correspond with the vertical one; and, of course, if the section be an *oblique* one, an intermediate structure would be observed. This remarkable fact is constant in all the coals I have examined, and a knowledge of it enables the observer to tell at once whether any section taken at random was a horizontal or a vertical one. How strangely different this from the Torbane-hill mineral! Cut that mineral in any way you please, and there will be little or no difference in appearance. The structure of the transverse sections of coal is so very peculiar and so characteristic, that I must briefly point out the means it affords of distinguishing coal from any other modification of vegetable tissue. The peculiarity consists in this,—that, in the midst of a black opaque ground,

numerous brown transparent rings, each having a black dot in the centre, are interspersed; they appear like transverse sections of thick-walled cells or of woody fibres. In some coals they occur in close proximity to each other, as in woods generally: in other cases they are more or less separated, either by the black material before alluded to, or by a network of rather smaller rings, in which the central dot is absent. There are many coals, especially some of the common domestic kinds, in which it is difficult to recognise this structure in every part of the section; in these coals a rich brown structureless material—bituminous or not I cannot say—seems to be in excess, and so obscures the characteristic appearances of the rings. In longitudinal sections the woody fibres are generally well seen, and a tendency to split in the direction of their length (as shown in Plate III., fig. 5), may always be observed. Amongst the fibres may be noticed certain elongated cells, of a rich brown colour, having a dark line running down through the centre: these are constant in all coals, and when divided transversely, appear as the rings before noticed. Their size is tolerably uniform in many coals (as shown in Plate III., fig. 2). Mr. Witham was acquainted with the differences between a longitudinal and a transverse section of coal, as may be seen on referring to the 2nd edition of his work on the “Fossil Vegetables of the Carboniferous and Oolitic Deposits;” both the rings and the elongated cells are well figured, and his remarks on the value of investigating the microscopic structure of coal, are very excellent. The absence of vascular tissue in the numerous sections of coal, made both by Dr. Adams and myself, would lead to the supposition that the wood of which it is composed must approach very near to that of the Coniferæ.

Examination of the Powder of Coal.—When coal is reduced to a fine powder, and examined either in water or in Canada balsam, it will be found to consist principally of short opaque cylinders or fibres, occurring singly or in bundles, and of angular dark-brown plates of various sizes, probably composed of bituminous matter (as shown in Plate III., fig. 7); the remainder of the mass is made up of minute transparent particles of silica, with an occasional mixture of fragments of cells and fibres. Many blocks of coal have a fine dull black powder on two of their outer surfaces, which will make the fingers very black: this I call the charcoal layer, and in it will be found fragments of woody tissue of cells, and even of vessels. My investigations lead me to believe that this layer is derived from plants which existed at the same time as the coal-wood, but were not capable of being converted

into true coal, but having been subjected to a great heat, their remains are left as a species of charcoal. Some specimens of the Torbane-hill coal have a large amount of this charcoal upon their upper and under surfaces, and in it, vessels of various kinds will occasionally be found, although such vessels do not occur in the solid coal itself.

Examination of the Ash of Coal.—The brown ash of coal, with the exception of particles, probably of silica, is almost wholly composed of vegetable remains, some of which properly belong to the coal itself, whilst others are derived from extraneous plants which have been mixed up with it. Every kind of tissue which has been described as proper to the coal may be met with in the ash, when not too much burnt. The remains of woody fibres and cells are the most common constituents, but flat, very opaque, irregular masses, such as are shown in Plate III., fig. 4, and which evidently correspond to portions of transverse sections of wood, are frequently found. Portions of siliceous cuticle, probably of grasses, as shown in fig. 6, from a drawing by Dr. Adams, are far from being uncommon. In short, when the indications of the woody structure of coal are very faint in sections, they are well exemplified in the ash. Sections of Welsh *Anthracite* (which I believe to be a fossil coke) are most difficult to obtain, and when made, afford very unsatisfactory evidence of vegetable structure: when, however, the ash is examined, the presence of woody tissue is unquestionable.

The Torbane-hill mineral has been most carefully examined by my friend Dr. Adams, and as his investigations were carried on independently of mine, it will be satisfactory that you should be made acquainted with the conclusions he has arrived at after a laborious series of examinations. They are as follow:—

“The most interesting example which could be adduced, illustrative of the differences in essential characters, as demonstrated by the microscope, between substances supposed by commercial men to be identical, is found in the Torbanehill mineral, known also by the name of Boghead coal. In the lawsuit previously alluded to, much of the scientific evidence regarding this mineral was of a very conflicting character, so much so that the court virtually set aside the scientific evidence, and decided on the legal merits of the commercial bargain.

“The importance of the interests involved, and the high character of the witnesses examined, have made this trial very celebrated; and it is from an excusable desire that the grounds of the opinion I expressed at the trial should be understood, that I now seek to place them on record. I will, however, confine my remarks to a very short summary of my observations made upon the Torbanehill mineral, leaving a fuller detail with my friend, Professor Quckett, who gave joint evidence with me, and with whom I have discussed and investigated the whole subject of my

present communication with a most pleasing and perfect accordauce of observation and opinion.

“The following are the principal results:—

“I. A very thin section of the Torbanehill mineral, when viewed by transmitted light, has a pale-yellow colour, is semi-transparent, and, with the exception of very slight variations in the depth of the colour, probably dependent on the varying thickness of the section, it appears to be a uniform homogeneous mass. *The same appearance is constantly presented notwithstanding that the sections are taken in various directions.* While this is the usual appearance of what may be termed the average specimens, viz., of portions taken from the centre of the block (or seam), yet, in sections taken from near the outside, or lower portion of the seam, I find a quantity of small opaque particles (evidently carthy matter) in the form of a fine powder, scattered through the yellow-coloured medium forming the mineral. In such specimens the transparent yellow substance forms irregular rounded granules, and the opaque powder is either sparingly diffused over, or forms an outline or partition, more or less perfect, around the exterior of the yellow granules. These granules vary much in size, being as small as 1-4000th of an inch, and of every intermediate size from that up to 1-200th of an inch in diameter.

“In sections taken from the outside, as above described, I have observed occasional patches of opaque material of every irregular form, and which I could not liken to any other substance, unless I spoke of them simply as specks of dirt. In the same sections I have also found stalks of plants and fragments of wood. These opaque patches and vegetable fragments are always *distinctly* isolated; that is, they do not in any way resemble or form part of the substance of the mineral, otherwise than by being involved or contained in it, and their presence, therefore, can only be considered accidental.

“II. When reduced to a fine powder, and examined under water, all the particles of the mineral have a clear, and generally a sharp outline, are of an irregularly rounded form, and may be described as of a uniform granular appearance. About 7-10ths of the granules are very translucent, and of a light amber or yellow colour. About 2-10ths of the particles (also translucent) partake more of a flat, angular shape, and are quite colourless, probably consisting of siliceous matter. The remainder of the powder consists of dark semi-opaque particles.

“In specimens of powder taken from an outside portion of the mineral, there is observed a larger proportion of the semi-opaque particles, together with the occasional appearance of vegetable stalks, rough fibrous fragments, and delicate fibrils of microscopic plants. With these special exceptions, the powder gives no trace whatever of organic structure.

“III. The ash of the mineral, when examined under water, presents a considerable quantity of the colourless particles already described, lying at the bottom of the fluid, while a filmy particle of transparent particles floats on the surface. No trace whatever of organic structure is here observed.

“Polarised light does not in any way affect the appearances of the mineral.

I have, in consequence of these investigations, a firm conviction of the non-identity of the Torbanehill mineral with coal, setting aside those inferences which may be found to exist under mineralogical, geological, or chemical investigation. I cannot conceive how the evidence of *Amorphisin* in the one case, and of intimate vegetable composition and of regular structure in the other, can be explained away, or any other view than that of non-identity of physical structure. In coal we find a well-characterized organization, or regular arrangement of its component parts

so distinctly peculiar, that I should question the competency, at least, of any party who, after comparing the microscopic appearances of the two substances in question, could hint at a resemblance. The Torbanehill mineral, on the other hand, is as thoroughly devoid of organic structure, or of any regular arrangement of its component parts, as is a mass of jelly or a conglomerate of masons' mortar."

I will now, in the third place, proceed to read the evidence given by the witnesses for the pursuer and the defender.

Professor QUEKETT.—*Examined by Mr. MACFARLANE.*

You are one of the Professors in the Royal College of Surgeons in London?—Yes.

What chair do you occupy?—The chair of Histology.

What is the object of that study?—An examination of the minute tissues or structure of plants and animals.

I believe you have devoted a great deal of study and attention to that subject?—Yes, for the last twenty years.

You have published a catalogue of the preparations in the College of Surgeons of London, descriptive of the various tissues?—Yes.

And you have yourself a very extensive collection?—Yes, I believe the largest in Europe.

You conduct your investigations with the aid of the microscope?—Yes.

And have you made careful investigation into the structure of the various coals, as well as other minerals?—Yes.

Have you in this way had occasion to examine the most of the known coals in England and Wales?—Yes, about seventy varieties.

Have you also examined varieties of Scotch coal?—Yes.

What have you discovered to be the tissue of coals?—They show us a woody tissue.

Have you found structure of that description in all the varieties to which you have referred?—All the varieties of coal.

More or less distinct, I suppose?—Yes.

Now, have you examined the Torbanehill mineral?—Yes, in every possible way microscopically.

Were specimens of the mineral delivered to you?—Yes, some time ago.

By whom?—By Mr. William Forbes and a Mr. Rettie. I have the specimens here.

Now, did you subject those specimens to a very careful examination?—Yes, very careful.

You tried them in every possible way, and repeatedly?—Yes, and repeatedly.

Did you make a great many sections out of them?—Yes, an immense number.

So as to give you every possible opportunity in tracing their structure?—Yes.

What result did you come to?—That the Torbanehill mineral is different from anything that I ever saw in my life before.

Did you discover any trace of organic structure?—Yes, when plants are accidentally mixed with it.

You were enabled to ascertain when it was so?—Yes.

Perfectly?—Perfectly.

But in the substance itself?—No structure—that is, what the microscopists would term an organic structure.

Is it different in that respect from all the varieties of coal you have examined?—Decidedly so.

Did you get illustrations?—Yes, I have illustrations. (Produces same.) I think you will come to a better understanding of the thing from those illustrations than from the specimens.

Explain what that is (referring to illustration shown to the jury).—This is a section of the Torbanehill mineral, or rather a granular section, and in it you will observe *some yellow matter* that burns—whether bituminous or resinous you must go to the chemists for. The black part is the strictly mineral part.

What is the mineral matter to which you refer?—It is the dark granular matter.

Lord-President.—I understand that these illustrations show the bitumen and the mineral at different places?—Yes, my Lord.

Mr. Macfarlane.—Now, then, do the illustrations of your coal investigations exhibit a different appearance?—Decidedly.

Now, you say the mineral substance there is granular, is it so in the coal?—Not at all, except when visible to the naked eye. In coal, you can see mineral structure by the naked eye, but to that I do not allude; but under the microscope you can tell that is a totally distinct thing from the coal itself. What I mean is, that in specimens of coal you can often see crystallized matter with the naked eye.

Is that extraneous?—I would say so.

But when subjected to the microscope?—It exhibits a totally different structure. It is not granular; it depends entirely on which way the specimen of coal is cut. If cut in one direction you will either see a cellular or fibrous appearance.

Indicative of what?—Woody tissue.

You have, I suppose, made sections in all the specimens of the Torbanehill mineral—in all the various ways you have made sections of the coal?—Yes.

And you have found in all the different sections a decided difference, showing them in your mind to be different substances?—Certainly.

Then, judging from all your experience and investigation, do you consider this Torbanehill mineral to be a description of coal or not?—Certainly not.

Have you any illustrations of coal there?—Yes, I have a most remarkable illustration—perhaps the jury will understand better by this than anything else. I have here a section of the mineral and coal in juxtaposition; this has been cut by Mr. Bryson, lapidary, and you will be enabled to see whether coal or mineral. The woody section is shown by the dark colour, the mineral by the other.

Are those illustrations of longitudinal, or transverse sections, or what sections?—That of coal is longitudinal, and of the mineral it is supposed to be the same, because they are in juxtaposition.

Suppose a transverse section—what difference?—In the Torbanehill mineral a section at right angles would present precisely the same character, but the coal would present another character, that character being shown in this lower drawing (exhibiting it to the jury). You will notice that the coal runs through that mineral. You can trace it by its minute tissue.

You examined some of the Scotch varieties of coal?—Yes, many varieties.

Did you examine the Methil?—Yes, of two kinds, I believe known by the names of the brown and the black.

Did you discover vegetable structure there?—Yes.

Decidedly in both?—Decidedly in both.

And in that respect different from this Torbanehill mineral?—Certainly.

You mentioned at one time that you had observed the presence, in some of those coal specimens, of fossil plants?—Certainly.

Could you see them with the naked eye?—Yes, in those specimens of the Torbanehill.

Have you seen them in coal in the same way?—Yes, but I consider them extraneous or isolated examples.

Cross-examined by Mr. Neaves.—Is the structure of coal uniform in general?—It is so far uniform that the various transverse sections are uniform, and so are longitudinal.

Equally visible in all places of the coal?—Yes, in all places, except, as I have stated before, where you have mineral that is foreign to the coal.

What mineral matter do you allude to?—The chemists must decide that.

You only speak to appearances?—Yes.

And the same formation in all?—Yes; the plants differ; I believe there are two kinds of plants or tissue that essentially form coal.

But they present the same appearance?—Yes, but those plants are not traceable in the same specimens of coal. That in the neighbourhood of Glasgow may be different from the coal found in the neighbourhood of Edinburgh.

Can you distinguish the one plant from the other?—Yes, in the longitudinal section.

And you never found any portion of any coal without exhibiting the same permanent structure?—Certainly not.

Where did you get that specimen you showed us of the two coals together?—That was taken by Mr. Bowerbank from the mine two or three days ago, and the drawing was taken from a magnified representation of one of the sections.

Lord President.—Let us take down what those specimens are if they are to go in, but I thought they were to be taken away by the witness.

Dean of Faculty.—No. 25 represents that yellow matter of which the witness spoke; No. 26 is the drawing of that highly-magnified section; Nos. 28 and 29 are the specimen and the drawing; and No. 27 is the appearance presented by the two different sections of coal itself, the one longitudinal and the other transverse.

Witness.—There is one thing I would wish to state, this—I came here to speak the truth, and it may be testimony for or against my evidence, when I say that all that which may be supposed like vegetable structure in the Torbanehill mineral disappears when the structure is thin.

Dean of Faculty.—When you speak of that which appears as vegetable structure, you mean those isolated fossil plants?—Yes. I would also allude to the fact that a book was published in this city twenty years ago, by Mr. Witham, of specimens made by Mr. Nicol; and this was the first representation of this vegetable structure.

Dr. JAMES ADAMS.—*Examined by Mr. MACFARLANE.*

You practise as a medical man in Glasgow?—I do.

Have you devoted a good deal of time and study to observations by the microscope?—I have.

For a considerable time back?—For many years.

Have you subjected to examination by the microscope various minerals?—I have.

Extensively?—Extensively.

Varieties of Scotch coal?—Yes, a great many.

Most of the known varieties?—Most of the known varieties.

Have you examined the Torbanehill mineral?—I have.

Recently?—Recently.

And did you subject it to a very careful investigation?—Very careful.

In various forms?—Yes.

Now, will you tell me what those Nos. of process are, No. 259 to 263, both inclusive?—259 represents sections of various specimens of the Torbanehill mineral, as seen under the microscope.

From the centre of the same, from the outside or bottom, and also from the outside of block?—Yes.

What is the next No.?—260, representing two sections of coal, termed to me cannel coal—Duke of Hamilton's cannel coal; the one represents what I have termed a longitudinal section, and the other a transverse section, drawn by myself.

The next No.?—Is 261. This represents a drawing of what was termed to me Lesmahagow, Ferguson's cannel coal—two sections drawn from specimens made by myself; but the drawing made by an artist named Donald, of Glasgow, under my eye.

And you have no doubt they are correctly done?—No doubt; very faithfully made.

The next No.?—262, representing sections of—1st, what is termed Jordanhill cannel coal. The one is longitudinal of Jordanhill, the other is a transverse section of a coal called Cowdenhead, given to me. This one, 263, which represents three drawings—two transverse and one longitudinal; a transverse section of Jordanhill cannel coal, drawn by a medical gentleman of the name of Risk, under my eye, a faithful delineation; the other is a drawing of cannel coal procured from the Glasgow Gas Works, called Knightwood coal; and there is also a longitudinal drawing of Knightwood. Those three drawings were made under my eye by Mr. Risk.

Did you subject the powder of the Torbanehill mineral to the microscope?—I did.

Having applied a little water?—Yes.

What did you discover to be the particles?—Those particles have a clear granular shape, they are of an irregular rounded form, and I say may be described as exhibiting an uniform granular appearance.

Any further description?—About $\frac{7}{10}$ of those granules are very translucent, and of a light-amber colour. About $\frac{2}{10}$, also translucent, partake more of a flat or angular shape in their outline, and are quite colourless; and there are a few particles of a dark or semi-opaque matter.

Now have you examined coal specimens in the same way?—I have.

What were the results?—They differed very materially; the particles of cannel coal which I took as being the more compact coal, are found of various sizes, and in form generally flat, angular, or oblong, with fibrous character; the edges generally rough and as darkly opaque as in the centre.

Have you examined the ash of the Torbanehill mineral?—I have.

When you said that the coal particles were of different sizes, were the particles of Torbanehill mineral of various or the same size?—When I examined them under a high power I found the Torbanehill to be also of various sizes.

You examined them with the aid of a microscope carefully?—Yes.

What results?—I found it very difficult to describe the appearance, because it seemed to consist of a film or congeries of structureless particles. I got nothing tangible almost to lay hold of. I consider most of those consisted of the colourless particles which I have mentioned as having been found in the powder, viz., the flat, angular, and perfectly transparent particles.

I understand, Doctor, when you say perfectly structureless, that there was no organization?—No organization; they have form.

No trace of vegetable origin?—None.

Nor the coal ash?—In the coal ash examined under water, I found abundant remains of vegetable structure, examined in the same way.

Woody tissues in the coal?—Yes.

Did you conduct your investigation of the ash of the Torbanehill mineral and of the coal both in direct and transmitted lights?—By both.

And with the results which you have described?—Yes.

Were they the best, most approved instruments?—They were. I have used various instruments of all kinds, but I have used the best and most recent construction.

What were those?—Those were prepared by two of the most eminent London opticians, Mr. Ross and the firm of Smith and Beek.

What conclusion do you arrive at in regard to this Torbanehill mineral, keeping in view your investigation of the sections, of the powder, and of the ash?—That the two substances are totally dissimilar.

That the Torbanehill is a different substance from any coal with which you are acquainted?—Yes.

Cross-examined by Mr. Neaves.—Are you in practice in Glasgow as a physician?—I am.

Have you marked the magnifying power of the instruments used on those specimens?—I have.

When did you first see this mineral?—I think on 15th January last year.

Had you never seen it before?—Never to my knowledge.

You had previously been in the habit of examining coals?—I had.

And had seen all the cannel coals?—Not then. I have since examined them.

What coal had you seen when in the practice of examining before?—Chiefly domestic coal.

For many years?—For several years.

With any particular view?—None.

The body and ash of domestic coal?—Yes.

You always see the woody structure in the ash?—Always; I have never failed.

And in the coal?—Do you mean the sections?

Yes.—I have never met with a piece of coal that had not those appearances.

Do you give it a name?—I call it a fibrous section, from appearing like a bundle of fibres in one direction. I give it longitudinally, because it gives me the idea of length, and annular, that is, composed of rings, when seen in a cross cut with a longitudinal.

But are equally distinct in the same coal always?—Not equally distinct.

Not equally distinct in all coals nor in the same coal?—No, but remain always distinct in every coal.

Re-examined by Mr. Macfarlane.—Have you been at Torbanehill?—Yes.

And made specimens?—Yes.

Did you examine from those specimens?—Yes.

Fair or average specimens of the mineral?—I took them just as they were raised from the pit, and examined them from the centre, outside, and every way I could possibly conceive.

Your observations have been more recently directed to cannel coal?—Yes.

Can you give me the names?—I believe I have examined about forty or

fifty different specimens, as far as I know, but I can give the names of different coals that I tested.

Just give us a few?—These were Capeldrac, Wemyss, and Pirnichill, &c.

Your investigations had been previously chiefly directed to the ordinary coals?—Yes.

Is it more difficult to trace the organic structure in the cannel coal than in the ordinary domestic coal?—It is.

Perhaps requires more skill and practice?—Yes, in conducting the investigation into the cannel coal.

What is the reason of that?—The reason I believe to be, that the structure is much more compact in the cannel coal, and the section requires to be made exceedingly thin, and it is very difficult to procure that condition, from the excessive brittleness of the material, and also intense opacity, and containing particles of hard matter, which frequently tear out the specimens.

Mr. BOWERBANK.—*Examined by* Mr. MACFARLANE.

Mr. Bowerbank, you live in London?—I do.

You have given a good deal of your time and attention to microscopical observations?—I have for these twenty-five years past.

You are a fellow of the Royal Society?—I am.

You were lately president of the Microscopical Society of London?—I was.

And you have written on the subject, I believe?—I have.

Have you made a great many examinations, with the aid of the microscope, of mineral substances?—I have.

Of various descriptions of coal?—I have. For many years, the subject, simply as a natural-history subject, was much inquired into.

And you have turned your attention to it?—I have.

And have for several years been taking observations, with the microscope, of coal substances?—Yes.

Have you been at Torbanehill?—I have.

Recently?—Yes, recently.

And you obtained specimens of the mineral that is working there?—I did.

And subjected them to examination?—I have.

Did you give a specimen last week to Professor Quckett?—I showed him a specimen, and he desired to possess it for examination.

And did you give some specimens to Dr. Adams?—I did.

What has been the result of your examination of coal substances?—Every coal which I have examined, either by sections, or by external characters, or by the examination of the ash, has convinced me that it is an essential character of coal that it should be composed principally of organized vegetable substances and bitumen.

Lord President.—Of what, did you say?—Of organized vegetable carbon and bitumen principally.

Mr. Macfarlane.—With a little earthy matter?—Yes.

I think you said these examinations were of the sections of the substance, and of the ash as well?—Of the sections of the coal matter, and of the ash as well. The practice generally adopted in examination is, first to observe its ordinary characters, and next its sections, so as to develop its structure.

Have you pursued the same mode of investigation in regard to the Torbanehill mineral?—Exactly.

And with what result?—I have found no organic structure in it,

although I have examined it by powers varying from 40 or 50, up to very nearly 700 linear. I have also examined the ash with great care; and I may say that as to almost every specimen that has passed through my hands identified, and others as well, in no case have I found any indications of vegetable structure in the ash.

Then the results of your examination of the coal, and of this mineral, are very different?—Quite opposite.

I suppose, Mr. Bowerbank, you have used the best instruments?—Yes, Sir, I believe there are no better to be procured. Indeed, unless they were instruments of a high optical character, they would not develop the minutest portions of the tissue satisfactorily.

Who are the great London makers?—Ross, Powell and Smith, and Bett (or Beek).

You have examined, I suppose, different varieties of shales, have you?—To a very considerable extent.

Any traces of organic structure in them?—Not in the body of the shale itself, but a great intermixture of isolated plants. In fact, in coal shales isolated plants form a considerable portion of them.

We have had the word ‘amorphous’ used frequently, Mr. Bowerbank. Can you explain its meaning?—I understand an amorphous mass of that description to be a mass without crystallization—a mass which would cleave in any direction without any determinate arrangement. For instance, I would say a sandstone, although formed of granulated masses, is still an amorphous mass, as there is no determinate arrangement.

Where there is organic structure, the word amorphous would not, of course, apply?—Not to the structure itself, but it may apply to the medium in which that structure is imbedded.

Cross-examined by Mr. Neaves.—Where did you get your specimens?—Some from Torbanehill pits, which I visited within the last week.

And adjoining properties?—And some from the adjoining properties as well.

What property was that?—Bathgate pit, and another pit. I also received verified specimens sent from the country to request an examination of them.

You first saw the mineral there?—I first saw the mineral at Queenwood College, some time ago.

Some months ago?—About three months ago.

Re-examined by Mr. Macfarlane.—Among other coals have you examined various cannel coals?—Frequently.

And the statements you have made have had reference to them as well as to others?—The specimens which I have examined of the cannel coals, vary very considerably in character from this new mineral from Torbanehill.

You discovered the vegetable origin of the structure in them?—Oh, yes.

This closes the evidence of the microscopists on the pursuer’s side. I will now proceed to read that given on the side of the defender.

Professor J. H. BALFOUR.—*Examined by Mr. NEAVES.*

You are Professor of Botany in the University of Edinburgh?—Yes.

And I understand that you have devoted attention not only to the subject of botany as concerns existing plants, but also to fossil botany?—Yes.

Is that a part of the course that you teach?—Yes.

In the course of teaching that class, are you in the habit of examining mineral substances with a view to noticing their structure?—I examine fossil plants. I have a large collection of specimens of fossil plants.

Have you been in this case shown some specimens of different minerals with a view of examining them?—Yes.

What were they?—I have seen specimens of the Torbanehill coal, the Methil coal, the Capeldrae coal, the Lesmahagow coal, and several other parrot and other common coals.

Did you visit the ground at Torbanehill?—Yes, I went to the pits and examined the coal, and brought specimens from the place.

Did you visit the Methil pit?—Yes.

And got some specimens from Methil?—Yes, out of the pit.

And where did you get the other specimens that you refer to?—I got them from various sources. Some were sent me authenticated by Mr. Russel, some were given me by Dr. MacLagan, also by Dr. Redfern, Dr. Aitken, and Professor Harkness.

Did you make sections of these minerals with a view to a microscopical investigation of them?—Yes.

Did you make such a variety of sections as to enable you to judge in all directions?—Yes, so as to judge fully of the structure.

Now, from that examination, are you able to say whether you discovered in these specimens traces of organic structure?—Certainly organic structure.

In all the specimens?—In all the specimens more or less.

Now, in the Torbanehill mineral did you find marks of organic structure?—Certainly.

And in the Methil?—And in the Methil.

Was there any difference, or any resemblance, between the appearance of the Torbanehill mineral and the Methil mineral?—A remarkable similarity.

Was there some Lesmahagow coal?—Yes.

And some Capeldrae also?—Yes.

And I think some Kinneil coal?—Some Kinneil.

Which is a cannel also?—Yes.

Did you take the assistance of Dr. Greville?—I took his assistance in delineating what we saw under the microscope.

Did you see his delineations?—Yes.

Did they appear to you to be successful?—Most correct, I think.

You believe coal generally to be a vegetable formation, I suppose?—Certainly.

Of what species of plants is it generally supposed to be composed?—The coal plants are numerous. We have, in the first place, a mass of ferns, stigmarias, sigillarias, lepidodendrons, calamites, and various other genera.

The ferns supposed to form coal-beds are very gigantic ferns compared with the present ferns?—They are tree ferns.

Is it a cryptogamic plant?—Yes.

In such plants, what is the particular appearance or structure you would expect to find?—In all these plants, as well as in other plants of a woody stem, we have cells and vessels; but in the tree ferns we have a structure which may be said to be pretty regular, which is called scalariform, or ladder-like, from the bars visible upon it. They are vessels or tubes.

Did you see in the Torbanehill coal appearances that seemed to you to indicate cellular structure?—Certainly.

No doubt of that?—No doubt of that.

And also some appearances indicative of scalariform structure?—Yes.

The cellular appearances more generally diffused than the other?—Yes, much more generally.

Do you consider you have in that way evidence of the vegetable composition of the Torbanehill mineral?—Yes, certainly.

And of the same character generally as the other cannel coals that you examined?—Precisely.

[Here several drawings were handed to the witness, and he was asked to explain them.

In the first drawing, which was of the Torbanehill mineral, witness stated the sections showed the vegetable structure, and also the scalariform vessels, with the bars upon it, very distinctly.]

Is that the kind of structure that is seen in modern tree ferns?—Yes.

The next drawing exhibits three sections,—the Lesmahagow, the Capeldrae, and the Torbanehill coal,—showing precisely similar structure. They are a little different in colour, but the same in structure. There are also sections of the Torbanehill and Methil in the drawings, showing the same appearance and structure in both these. Another drawing of the separate individual shales shows distinctly the appearance of separate cells, both in the Torbanehill coal, in the Lesmahagow coal, and in the Capeldrae coal. And, in fact, we find these in various other coals.

The cell is the base of the organic structure of these vegetables?—Yes.

It is the accumulation of cell upon cell that builds up the structure?—Yes.

Judging microscopically, then, and also with your knowledge of fossil botany, would you draw the inference that the Torbanehill was of the same, or of a different class of substances from the other cannel coals that you have mentioned?—The same class as of the cannel coals I have seen.

The only difference, I understand you to say, is the difference in the tinge of colour?—Yes, and that occurs in many coals.

You don't think that essential in deciding the question?—I do not.

Cross-examined by the Dean of Faculty.—These observations are made upon a thin section?—Yes.

Who made the sections?—They were made by Professor Harkness, Dr. Aitken, Dr. Redfern, and Mr. Glen.

Would you mark upon each the name of the gentleman who did them?—Yes, to the best of my recollection.

[Here witness marked each section as requested.]

Have you yourself been accustomed to make such sections?—I have made sections for the microscope.

Have you much practice with the microscope?—Yes, it is part of my course.

In reference to existing plants?—Yes, and also to fossil plants. I have a large collection of fossil sections.

With regard to this drawing here [holding up one of those previously described by witness], that represents the impression of an individual fossil plant?—That represents only a portion of a plant, the vascular part of the vascular tissue of a plant, approaching nearly to the scalariform tissue.

Do you mean that the tissue is there, or the impression on the plant?—The tissue is there.

In this other portion of the seam, then, which is coloured brown, you do not observe any structure?—I did not examine particularly.

But does this represent what you saw on that occasion?—Yes.

Then there is no appearance of structure there?—I cannot say.

There is no structure represented there?—No.

All that you found in this particular section is the representation of part of a fossil plant?—Yes.

Part of an individual plant apparently?—Part of an individual plant probably.

Do you know from what portion of this seam of Torbanehill mineral this slice representing the upper drawing is taken?—I do not know the portion of the seam.

Do you know the portion of the seam from which any of them were taken?—I have only seen the specimens. They seem to be the ordinary appearance of the Torbanehill mineral, and quite the usual appearance of the coal, so far as I saw.

Here the Dean of Faculty took up another drawing, and asked witness if he saw anything similar to that?—I saw appearances similar to that.

Have you represented them?—Represented them so far in some of these sections, only the dark colour between makes a difference in the appearances.

Lord President.—Is that in the Torbanehill mineral?—Yes.

Dean of Faculty.—Did you see anything like that [showing witness another drawing, No. 25]?—Something approaching to this. It wants, in some respects, the regularity of the structure I have seen in the other.

Shown No. 26, another drawing, and asked if he had seen anything like that?—This also approaches to what I observed, but wants the definiteness and regularity of the structure I saw.

Did you see anything like that [showing No. 28, another drawing]?—Yes, the yellow part is more like what we saw in the general structure.

What power did you use in making these observations?—They are marked in diameters; two of them were 200, and the other 70.

Have you ever examined shales in this way?—I have looked at one or two shales. It is not so much in my way as plants.

Do you find marks of fossil plants in them?—Yes, they occur; but the structure is different in them. They have not the same marked definite form I have seen in the others.

I understand that in these you represent both the transverse and the parallel sections?—Yes, we have taken them in two directions.

Which are the transverse?—The three upper are the longitudinal, and the lower the transverse or horizontal.

What do you mean by horizontal?—By horizontal we mean cutting off the ends of the vessels.

That is to say, you learned that from the gentlemen who made them?—I have examined sections.

You did not see the sections made?—No.

Then, of course, you could only get the information from those gentlemen who made them?—Yes.

Are the three upper cut along the stratum, as it were, off the top of the stratum as it lies?—I am talking of them as regards the appearances we see in the microscope. Judging from ordinary structure, in the one case we cut the ends of the vessels; in the other, we cut along the line longitudinally.

Lord President.—The three upper are cut along the line of the vessels, and the three others are cut across the line of the vessels.

Dean of Faculty.—Do I understand you to say that you were told they were cut in this way, and that that is the ground of your saying so; or do you form your opinion by the appearance they present?—I was of course told so; and on looking at them, I should say they are so cut.

Then it is from both these reasons that you say so?—Yes.

Did you examine any part of the ashes of this mineral with the microscope?—No.

Did you ever examine the ashes of coal with the microscope?—No.

Did you use direct or transmitted light in these examinations?—I used generally transmitted light, but I also viewed some specimens by direct light.

Re-examined by Mr. Neaves.—There are several drawings here. Did you examine a great many more cuttings than these drawings?—A great number.

How many more, do you know?—I cannot tell the number of the sections of Torbanehill; at all events, some eight or ten, besides sections of other coal.

And then made a drawing of these?—Yes, as being average specimens.

Did you see some of these sections made?—Yes, these were the sections made under my direction by Mr. Glen.

The Methil section?—I cannot say I saw it made in the sense that I saw the whole process gone through, but it was done for me, by my direction, from a piece of Methil coal.

Lord President.—Did you see Mr. Glen make some of the sections?—I should rather say that the sections I allude to were made under my direction, and were authenticated by me at the time.

Mr. Neaves.—In the other sections of the Torbanehill mineral which you have examined besides this, did you find the same appearances?—The same appearances.

I forget what you said as to this yellow part of No. 28?—I considered that to be a cellular structure.

The yellow part included?—Yes.

This cellular tissue is a magnified appearance of the separate individual cells?—Yes.

With the view of showing that they were at larger power?—These are cells which occur in these coals, and they are separated the one from the other. We took magnified drawings of them.

Occurring at Boghead?—Yes, and on the others.

And besides showing those things, you formed an opinion of what they were?—Yes.

That they were the indications of vegetable cellular structure?—Certainly.

Lord President.—That is, the appearances in the mineral seams?—Yes.

Mr. Neaves.—Including the Torbanehill?—Yes.

And of that yellow part of the representation of the Torbanehill mineral?—I believe it to represent vegetable cells.

In these plants I suppose the structure is but imperfectly understood?—I may say we do not know it so completely as we know all the plants of the present day.

The cells may be longer or shorter?—Yes.

They vary in their form?—Yes.

And that may affect the longitudinal appearance of the cells?—Yes.

I do not understand you to say that this is the mere impression of a foreign fossil, but the actual structure of the mineral at that place?—Certainly.

Dean of Faculty.—The individual plant is there lying in the mineral?—The structure of the plant—not the entire plant.

A part of a fossil plant is seen there?—Yes.

Mr. Neaves.—Forming a part of the coal?—Yes.

Dean of Faculty.—I understand, Dr. Balfour, that there is a part of the fossil plant here lying imbedded in something or other?—It is a quite dissimilar part as regards the appearance.

The plant must be there in order to give it that appearance?—It must be the structure appearing so distinctly as to be seen there.

Very well ; a plant is lying here upon another thing, which is here represented by a dull-brown colour ?—Yes, a part of the plant.

Mr. Neaves.—What did you say ?—That that is part of the structure of a plant which is lying there in the mineral. When you make a section of the mineral you come upon this, showing you that there was a plant.

At that part the mineral consists of that plant ?—Yes.

Dean of Faculty.—You have seen fossil plants in stone quarries ?—Yes.

Mr. Neaves.—You do not consider that an example of such an appearance ?—No.

Dr. REDFERN.—*Examined by Mr. NEAVES.*

Dr. Redfern, you lecture on subjects connected with the microscope in connexion with the University ?—Yes ; and teach the use of the microscope.

You are a Fellow of the College of Surgeons of London ?—Yes.

Have you been accustomed to the examination of substances by the microscope ?—Yes.

Principally of vegetable substances for some years ?—I have for many years been in the practice of examining vegetable structure by the microscope.

Both in recent vegetables and in fossil substances ?—I have.

Did you lately receive some specimens of different minerals, including some of the Torbanehill mineral ?—I did.

From whom did you get the Torbanehill mineral ?—I got some specimens from Dr. Fyfe, and some others from the Aberdeen Gas Works, in the presence of Mr. Leslie, the manager.

Did you subject these specimens of the Torbanehill mineral to microscopical examination ?—I did so.

How many sections of it did you take ?—Eighteen.

From the same piece, or from different pieces ?—From eight different pieces.

Did you or did you not find vegetable structure in these sections ?—I found vegetable structure in every section.

Have you examined different cannel coals with the same view ?—I have.

What cannel coals ?—I have examined Lesmahagow cannel coal, Capeldrae cannel coal, Wigan cannel coal, Methil cannel coal, and Halbeath parrot coal ; and also the Kinneil coal from Bo'ness.

In what way would you speak of the examination of these minerals, and of the examination of the Torbanehill mineral, in reference to the vegetable structure ?—I am quite convinced, that in the sections of these different coals there are parts which cannot be distinguished from each other.

Vegetable structure in all ?—In all.

And in some parts this mineral undistinguishable from the others ?—Certainly.

The Boghead mineral has considerable varieties of aspect in itself ?—It has.

Different shades of colour ?—There are black, brown, and spotted pieces—black pieces with brown spots.

In the lightish-colour portions of the Boghead mineral, what is that you saw ?—I saw vegetable cells in these portions.

The structure that you saw is cellular structure ?—Yes.

Besides the cells that you saw, what else did you notice ?—I noticed also woody fibre, or woody tissue.

Are there some yellow spots in this light-coloured portion of the mineral?—There are.

What do you think these yellow spots indicate?—They indicate the existence of vegetable cells.

Have you applied any test to endeavour to find out whether they were vegetable or not?—I have, Sir; I have many reasons for concluding that they are vegetable cells.

Would you mention your reasons?—I find that they can be perfectly isolated—they project upon the edges of all sections of the mineral—they are rounded—they are as uniform in size as the cells of other vegetable structures—the general appearance of the section is that of a piece of vegetable cellular tissue—the yellow spots do not act upon polarised light, or act upon it very feebly.

Generally speaking, do you consider that the Torbanehill mineral exhibits the same appearances of structure and position microscopically as the other cannel minerals?—It does.

Did you see Dr. Greville's drawings?—I not only saw the drawings, but I saw him make them.

You had long previously examined the minerals?—I had; long and carefully.

Do these drawings appear to you to represent the general character of the mineral?—They do.

And you believe these drawings to represent cellular tissue?—I do.

Your sections were taken at random from the general specimens that you had?—Certainly.

As fair specimens that you thought the mineral would exhibit?—That was my chief object in obtaining them from the Aberdeen Gas Works. I took the specimens for as fair average specimens of the Torbanehill mineral as I could obtain.

And they would have supplied similar representations as those Dr. Greville has given, in your opinion?—I am satisfied of that.

Cross-examined by the Dean of Faculty.—You say Dr. Greville's drawings represent the same thing that you saw?—They do.

Did you examine the ash of this coal?—Yes.

With the microscope?—Yes. I consider the examination of the ash liable to great sources of fallacy, and place no dependence upon it.

Your reasons?—I should not look upon the ash to make out the structure it contains.

That is not your reason, but a repetition of your opinion. What is your reason?—Because I would expect the greater portion of vegetable structure, if it existed, to be destroyed by the process of combustion.

Did you ever examine the ash of ordinary coal with the microscope?—I have not.

Dr. R. K. GREVILLE.—*Examined by Mr. NEAVES.*

Dr. Greville, I believe you have devoted a good deal of your attention to the study of botany?—Yes, it has been the principal study of my whole life.

And in connexion with that to the use of the microscope?—I may say, without exaggeration, that for many years I have used the microscope almost every day.

Among other branches of the vegetable kingdom, you have studied and written upon the cryptogamic family, which includes the ferns?—Yes.

And which requires particular use of the microscope in order to illustrate its fructification?—Yes. I may add that I have made the drawings of everything I have published from my own microscopical investigations.

I made drawings of the outline and structure of two or three hundred ferns alone.

Were you asked to assist some gentlemen using the microscope to represent the appearance of some sections of minerals?—Yes.

These are the drawings you made?—Yes.

Did you yourself look at various sections of the minerals besides those that you have represented?—I did, especially with regard to the Boghead mineral. I examined under the microscope eighteen different slices made from eight different specimens of the substance.

Were these Dr. Redfern's specimens?—Yes.

Did you discover vegetable structure in these?—Unquestionably, in the whole of them.

Did you examine some other minerals—some cannel coals that this gentleman had?—I examined all those coals of which the names are appended to the drawings. There is the Methil, Lesmahagow, and Capeldrae coals.

Now these are correct representations, to the best of your ability, of what they present?—They are; they might be more minutely finished, but they give, I hope, a fair representation of the structure.

Did it appear to you, from your examination of these different things, that they were the general structure of the mass, or any incidental structure?—I have no hesitation in saying that it was the general structure of every specimen, not incidental. I should consider it to be quite impossible it could be incidental.

Do you consider that there is a material difference or a substantial identity between these different bodies, as represented in these different minerals?—I do not. I examined the specimens of the three uppermost sketches, and the structure was so similar, that I considered them to be identical. There is a difference, but nothing amounting to anything essential in the structure. The Lesmahagow, Capeldrae, and Torbanehill are essentially the same. I may be allowed to add, that in each slice there is a difference in every part of that slice, so that you must be guided by the general view.

From your botanical knowledge, have you any doubt that these representations exhibit vegetable cells?—I have no more doubt of that than of my own existence at this moment.

Will you explain what that paper is?—[handing witness one of the drawings spoken to by Professor Balfour]—That drawing represents vegetable cells in an isolated state, scattered throughout the substance, and observable, I believe, in most coals—certainly in most coals that I have examined. It is difficult to say what they may be, but I have no doubt that they are vegetable cells, solitary cells. They may possibly be transverse segments of cells, but I would not venture to say anything more than that. I believe them to be vegetable cells.

Found in this mineral?—We have found these vegetable cells in the Boghead as well as in others.

Will you explain what these two drawings represent?—[handing witness two of the drawings spoken to by Professor Balfour]—The uppermost one represents cellular tissue in the Torbanehill mineral; and, upon the whole, I consider that as one of the most satisfactory specimens which I examined; the cellular tissue is so unequivocally marked, and so regular, that it may be compared to that of a recent plant. It is exceedingly well defined. What I have represented in the drawing is not in the least exaggerated. No person accustomed to botanical sections would hesitate in believing that to be cellular tissue. The lower drawing represents a beautiful specimen, but whether that is general in the mineral I could not

say. It represents a modification of the vascular structure of plants called technically the scalariform structure. I can compare it best by comparing it with an old basket. It is an unequivocal vegetable structure.

What occurs in its neighbourhood in the rest of the section?—This was the whole that I saw. The other portion was not ground so thin, and I could not see what it consisted of; but judging from the traces of these vessels at the extreme edges, I have no reason whatever to doubt, that if the remainder of the section had been ground sufficiently thin, we would have seen the continuation of that structure.

But the other cells that you described here are diffused through the entire mass of the substance?—In all the specimens I examined it was uniform throughout the whole. It was exceedingly well marked in the one that represents the transverse section of the cells.

You get the width of the cells more distinctly when you cut the transverse section?—You get the area more distinctly shown.

Cross-examined by the Dean of Faculty.—Can you explain to me what are infusoria?—Infusoria represent minute animals invisible to the naked eye—visible only to the microscope.

Where do you find them?—It is very difficult to say where you do not find them. Generally they are sought for in fluids.

You find them in minerals also?—I am not prepared to answer that question. I am not sufficiently acquainted with the subject to venture to answer it.

Then you cannot tell me what appearance they present when found in minerals when examined under the microscope?—No, I am not aware of their occurring.

Professor HARKNESS.—*Examined by Mr. YOUNG.*

Professor Harkness, you are Professor of Geology in Queen's College, Cork?—Yes.

You succeeded Dr. Nicol?—About six months ago.

You have devoted considerable attention to the study of geology?—I have.

And also to the examination of objects by the microscope?—Yes, so far as relates to fossil plants.

You have visited Torbanehill?—I have.

You went down one of the pits?—I was down two of them.

And examined the mineral as it lay in the earth?—Yes.

And made yourself acquainted with its geological composition?—I found it to occur in the proper coal measures.

Exactly in the position you would expect to find coal?—Decidedly so.

You found nothing whatever in its geological composition to lead you for a moment to doubt that it was coal?—Nothing; on the contrary, everything to induce me to believe that it was coal.

Did you form any opinion upon the mineral itself?—I formed the opinion, that from the appearance of the mineral it was a coal.

Did you take some specimens of the mineral away?—Yes, I did, for the purpose of making a more careful examination.

And after that examination you retained your opinion?—I did.

And your opinion now is that it is a coal?—Decidedly so, without any manner of doubt.

Did you make some sections of the mineral which you took away with the view of microscopic examination?—So far as regarded fossil plants.

Did you find the structure familiar?—I found the structure peculiar, and the fossils characteristic of the coal formation.

How many structures are there in coal and coal plant?—There are two

or three distinguishing characteristics, first the woody fibre, the scalariform tissue, and the cellular tissue.

Is this upon the examination of a great many sections?—Yes. That was generally, not mere accidental structure of particular pieces.

You saw a drawing made by Dr. Greville?—I was present when that drawing was made.

And that gave a sufficiently distinct idea of the course of examination?—Yes.

Of the Torbanehill and some other coals?—Yes; and the Lcsmahagow, Kinneil, Capeldrae, and some other cannels.

I believe the drawing was made from a section furnished by you?—That is a most beautiful specimen of cellular tissue.

This is the most beautiful specimen you have seen of woody fibre?—I distinguish woody fibre from cellular on account of the more regular formation of the cells.

You have no doubt that this is a vegetable product?—Not the least.

[Witness was shown the drawings illustrative of cellular tissue and woody fibre, and distinguished each with great precision.]

You know what shales are?—Yes.

Do shales ever exhibit vegetable structure?—As shales they do not.

How would you describe a shale?—There are several forms of shales. Supposing the coal to be so mixed with earthy matter as to be incapable of being used for fuel, then that would be called a coaly shale.

And when the coaly matter is so great in proportion to the earthy matter that it will burn?—I should consider this a coal.

And more or less pure according to the admixture of earthy matter?—All coals contain more or less of earthy matter, and accordingly the coals run into shales as the earthy matter increases.

When you come to a substance beyond which a substance will not burn, you would call it a coaly shale?—Yes.

It is very difficult to draw the line at the exact place?—Very difficult.

Has this mineral anything of the character of a shale?—Not the least, so far as I have been able to detect.

You have seen specimens of Methil coal, and examined them with the microscope?—Yes.

And did you find anything to distinguish the Boghead mineral?—So far as external appearance went, I could scarcely distinguish the one from the other, and there was also a great similarity in internal structure.

There are a variety of cannels which approach each other very closely?—In regard to the distinction between the two there is not a more common one than this, the capability of burning and being used for the purposes of fuel.

If the substance would burn, and could be used as fuel, you would say it was a coal?—Yes, I would.

If any substance is sold in the market as a coal, is it a coal?—Yes, I should think so.

There is no science against this?—None that I am aware of.

Cross-examined by the Dean of Faculty.—I suppose whatever comes out of the coal measures and burns by itself is coal?—No; I would not say that. You might get a fragment of bitumen, which would not be coal, and that burns by itself.

Is that the only exception?—I am not prepared to say that there are any other exceptions.

Fragments of bitumen would be an exception?—Yes.

The way by which you distinguish a coal from a shale, or a shale from

a coal, I understand is, that the one will burn, and that the other will not?—The one will burn without the mixture of any extraneous matter.

It will burn by itself?—Yes.

There are other distinctions; but this is the distinction upon which you rested?—Yes.

You were going to tell us that there were a number of kinds of shales. Tell me some of these?—There are some which are absolutely devoid of coaly matter—clay shales, which have no coal in them at all.

Any other distinction?—Yes; there are shales which I should characterize as bituminous shales.

How do they differ from coaly shales?—They differ inasmuch as they give a bituminous smell when struck by the hammer; and they yield bitumen to chemical solvents.

Do they burn?—Yes, they burn in some cases.

Where do you find most bituminous shales?—You find them in Cambridge and in Dorsetshire, in the higher beds of the oolite.

Do you find the Methil coal to be of a laminated and slaty structure?—I found some fragments that were laminated; but others present the conchoidal structure that you have in the Boghead, and is compost.

The Boghead is compost?—It is.

Is the Methil coal so?—It is generally so.

But portions are slaty and laminated?—Yes.

Will you explain what infusoria are?—I have not given any opinion as concerning infusoria.

But you can give one?—They are minute microscopic animals.

Where are they found?—I generally find them in water.

Are they not to be found in minerals?—I have not found them in minerals.

But are they not to be found in minerals?—They are found in certain mineral beds, but I have not found them in mineral beds.

DR. WILLIAM AITKEN.—*Examined by* MR. PENNEY.

You made some sections of the Torbanehill mineral, and of some other coals?—Yes.

Were they for your own examination, or some that Dr. Greville drew?—I did some, and also for my own.

You got the returns from Torbanehill?—I did.

From the pit mouth?—Yes.

You made the sections fairly for the purpose of testing?—Yes.

Mr. Neaves then stated that they would not require to examine Mr. Glen, as his sections were also admitted.

Having now read to you the evidence given by the microscopists on both sides of the question, I cannot refrain from making a few remarks on some of the statements of the defender's witnesses. The subject to me is a painful one, for it is always with feelings of regret that I venture to differ in opinion from any scientific observer; but, however contrary to my inclination, I have a public duty to perform, to say nothing of the character I have to sustain amongst you as a member of this society. I sincerely hope, however, that those gentlemen will take it all in good part, and believe that it is only for the reasons above assigned, and not from any

public or private feeling of opposition to their opinions that I appear before you this night.

I will not dwell long upon the subject, as it must be very clear to you all—first, that the specimens examined by these gentlemen must have had more or less of plant structure imbedded in them; secondly, that they have evidently mistaken the peculiar arrangement of the combustible and earthy portions of the mineral for vegetable cellular tissue. Thirdly, they can certainly never have examined sections of many coals microscopically, as one and all tell you that they saw the same structure in the mineral as they did in coals. Had they made sections of coal in two directions, at right angles to each other, they could hardly have failed in seeing, almost at a glance, how much the sections differed in structure the one from the other. That such is really the case, even in the coals which they state in their evidence they have examined, may be shown by reference to Plate II. In fig. 1 is represented a transverse section of the so-called brown methil; and in fig. 2, a longitudinal section of the same. The two structures are so different in appearance, that, had such sections been made, I feel confident there could not have been a second opinion on the subject. In fig. 3 is shown a transverse section of the black methil, and in fig. 4 a longitudinal section. The differences, if anything, are even more striking than in the brown methil. But what will be said of figs. 5 and 6, which represent a transverse and longitudinal section of Lesmahagow cannel coal? That anything at all resembling such a structure as this, can be found in sections of the mineral in question, except when coal is present, I emphatically deny.

Now, granting for a moment that the structure of the mineral be cellular, what plants, I would ask, could the cells have belonged to? Can any botanist produce a single instance of a recent or fossil plant of the same thickness as a seam of the Torbanehill mineral, which shall be made up of a mass of cellular tissue, that is, without vessels or woody fibres being present with the cells?

Again, if the structure be cellular, we should expect to find the most durable part of the cell—the cell wall—always present, which is not the case. If this view be correct, the yellow particles being solid must be the contents of cells, they certainly cannot be cells. The cell-wall also, as far as we know it, in recent and fossil plants, always presents on section a more or less uniform thickness and a homogeneous appearance; whereas the structure around the yellow particles in all

cases, except where plants are present, is minutely granular, being in reality the clayey or earthy ingredient of the mineral.

None of the defender's witnesses, it appears, ever examined the ash of coal; and one witness in particular, Dr. Redfern, stated that the examination of "ash in general was liable to great sources of fallacy, and placed no dependence upon it;" whereas, it subsequently appeared that he had never examined the ash of ordinary coal with the microscope.

Were I disposed to be hypercritical, I could mention many other points in the evidence that I entirely dissent from; but I trust I have already said enough, and will therefore sum up my remarks by stating that I consider the mineral in question is not a coal, being structurally different from all undoubted coals, including those with which it appears it has been compared by the microscopists engaged by the defender. In order, therefore, that the scientific world in general may have an opportunity of judging for themselves whether this statement be correct or not, I have put specimens of the mineral and of these coals into the hands of the preparers of microscopic objects, and in a short time sections will be on sale by them and by the principal opticians in this metropolis.

I might by some persons be accused of unfairness in making even these few remarks upon the evidence of the witnesses for the defence, when they are all located in different parts of Great Britain, and therefore not able to be present this evening to answer for themselves. I wish, however, that they could have been here, and more especially if they could have brought with them the sections upon which their opinions were formed, and the drawings which were produced in court. They might say, perhaps, that it would not be fair play to send their specimens, their drawings, and their remarks into an enemy's camp; on my own part, however, I can venture to state that I am ready to appear before any tribunal of scientific men in this kingdom, and my drawings and specimens shall be open to all who may be interested in the subject, to examine for themselves. I beg it may be expressly understood, that should there be any one point in this paper which on subsequent investigation may turn out to be incorrect, I shall be as ready to come forward and acknowledge myself in error as I now am to express an opinion not hastily formed: my only object, as I said before, is truth; and by truth I will abide.

There is one other circumstance that I would briefly allude to before drawing my remarks to a conclusion, and this is a

portion of the Lord President's address to the Jury, in which, as before stated, Mr. Bowerbank and myself are placed in no very enviable position ; it is as follows :—

“ Besides those gentlemen who were examined as geologists and chemists, and who differ so widely, there was examined another class of men, and possessed of great attainments—I refer to the microscopists. One of them was the late President of the Microscopic Society of London—a learned body, who make it their object to pry into all things. Three of these gentlemen were examined for the pursuer, and four for the defender. The pursuer's witnesses told you that there was no trace of organic structure, no woody fibre or tissue, in short, no trace of vegetable matter in this substance, although occasionally there might be the incidental presence of vegetable remains. The witnesses of this class on the other side told you, on the contrary, that in every part of it there was the most clear vestiges of vegetable structure. I do not know, when I have so many geologists and so many microscopists telling me that it is not coal, and so many on the other side telling me the opposite, I say I do not know that I feel myself much the wiser, or further advanced in the inquiry. But if you have, in addition, a great number of chemists, and speaking with equal authority and equal contrariety, it is difficult to know what to make of the controversy. I do not know that I have anything to say against the skill of the microscopists, or the skill of any of those gentlemen ; but one general remark may be made on the microscopic testimony, and it is, that there are those who see a thing, and also those who do not see it—those who do see it, cannot see it unless it is there, and those who cannot see it do not see it at all. But very skilful persons looking for a thing and not seeing it, creates a strong presumption that it is not there. But when other persons do find it, it goes far to displace the notion that it is not there. But there is another observation on the microscopic evidence that occurred to me. I do not know whether I am under any misapprehension, but I think that three, certainly two, of those examined by the defenders, are botanists also ; and I do not think that any of those examined for the pursuer, two of them from London, represented themselves as botanists. Now, the defender's witnesses are accustomed to look for plants, and can understand them when they see them. The gentlemen on the other side again, looking for woody fibre or tissue, are not, as I understand, conversant or skilful in fossil plants. But finding such a difference of opinion, and such opposite conclusions arrived at by those persons, I do not know, unless you think that some gave their reasons more satisfactorily than others—I say I do not know that I feel my mind much relieved from the difficulties of this case by listening to all that evidence. It is very interesting no doubt, and if they were all standing on one side, and nobody standing on the other side, it might be very satisfactory to one's mind to listen to such evidence.”

To such remarks I would briefly reply that, however severe a counsel may be in his cross-examination, and however strong his language in addressing the jury may be, I think it to a certain extent excusable, as he is endeavouring to do the best for his client ; but I must confess my great surprise that a learned judge should see fit to single out one set of scientific witnesses from the pursuer's side, and hold them up, I would say, almost to ridicule ; that he did so on

the present occasion, the part of the address which I have just read to you will show. I think it will eventually turn out that the two members of the Microscopical Society of London, "that learned body who make it their object to pry into all things," are accustomed to look for plants, and *can* understand them when they see them; nay, I will assert that they can do more, for *they* can tell when a particular structure is not a plant. Had his Lordship been silent on the point, he would not have laid himself open to these truly justifiable remarks.

I would now, gentlemen, in conclusion, leave the matter in your hands. I think that the subject in question is one of the most important ever brought before the notice of this Society, and one which no set of men in this or any other country are so competent to investigate. Most of the members of this society are, as stated in the certificate for suspension, "attached to scientific pursuits," and most of them are in possession of the best instruments, and are accustomed to use them; let them, therefore, study the subject for themselves, and give independent testimony. Where, I might ask, can be found a correct definition of coal? I believe, at present, no such definition is extant, and it is on this account that I look upon the trial of Gillespie *versus* Russel, as one of the greatest importance to the geologist, the chemist, the mineralogist, and the microscopist; and I am of opinion that from it will spring, not only a perfect definition of coal, but of other combustible substances found in connexion with it, and, therefore, it is to be hoped that such contradictory statements as were made by the different scientific witnesses on the trial in question may in future be avoided. It remains, then, for the microscope, "that most valuable of all scientific instruments (to quote the words of Mr. Ross) ever yet bestowed by art upon the investigator of nature," to assist in deciding the true structure of coal, as it has already done that of many other organic substances of a previously-doubtful nature.

| | TORBANE-HILL MINERAL. | COAL. |
|--|--|--|
| <p>1. External characters . . .</p> <p>2. Characters exhibited by a cubical fragment, viewed as an opaque object, under a power of 50 diameters.</p> | <p>Colour, brown or black, tough, streak brown, without lustre.</p> <p>Granular, those granules or particles being of light-brown colour, which are detached from the general mass: any part, however black, will become brown, either by seraping or by raising it from the mass.</p> | <p>Colour black, brittle, streak black and lustrous; in the Brown Methil, dark brown and lustrous.</p> <p>Four of its six sides, in certain lights, will exhibit a fibrous appearance, like a longitudinal section of wood.</p> |
| <p>3. Characters exhibited by sections under the microscope.</p> | <p>Particles of various sizes, of circular figure, and amber colour, in some cases surrounded by a minutely-granular basis. When the particles are large, a radiated structure is present in the centre of each; no difference in structure whichever way the section is made. If plants, or portions of plants be present, they may be easily recognised by their rich brown colour, as well as by the form of their tissues.</p> | <p>Transverse and longitudinal sections totally different, but both agreeing with corresponding sections of wood. The presence of the so-called amber-coloured ring in the former, and the rich brown elongated cells and the fibres in the latter, are characteristic of all the coals which have been examined. In some coal, as the Brown Methil, a few yellow bitumenoid particles are scattered irregularly through the mass, but in most cases the bitumenoid portion is of a rich brown colour.</p> |
| <p>4. Characters of the powder .</p> | <p>Composed principally of the yellow particles, with occasional mixture of granules of earthy matter, some opaque, others quite transparent, and probably siliceous.</p> | <p>Composed principally of fibres or bundles of fibres; these are occasionally mixed with flattened angular plates of a rich brown colour; earthy matter sometimes present.</p> |
| <p>5. Characters of the coke and ash.</p> | <p>Coke, light and spongy, dull sound when struck, presenting a series of pits or cavities, from which the yellow particles have been removed by burning; the ash consists entirely of dark granules of earthy matter, and of angular pieces, probably of silicea.</p> | <p>Coke emits a metallic sound, and presents more or less of a fibrous appearance, and the ash always shows traces of vegetable structure.</p> |

DESCRIPTION OF PLATES.

PLATE I.

Fig.

- 1.—A section of the yellow variety of the Torbane-hill Mineral, as seen under a magnifying power of 130 diameters.
- 2.—A section of the dark variety of the Torbane-hill Mineral, as seen under a power of 130 diameters. The yellow circular masses exhibit a radiated structure; they form the combustible portion of the mineral, whilst the dark matter is the earthy ingredient.
- 3.—A section of the Torbane-hill Mineral, in which a specimen of *Stigmara ficoides* is imbedded: every part of this plant can be readily distinguished from the mineral by its rich brown colour. Magnified 6 diameters.
- 4.—A portion of the same specimen magnified 50 diameters, showing how easily the smallest portion of vegetable tissue can be distinguished from the substance of the mineral.
- 5.—A section of the Torbane-hill Mineral, through which a thin layer of coal ran, which may be readily recognised by its brown colour. The yellow particles of the mineral in contact with the coal are of more or less oval figure.
- 6.—The powder of Torbane-hill Mineral, showing the yellow bituminous particles, and fragments of vessels.
- 7.—Ash of the Torbane-hill Mineral.

PLATE II.

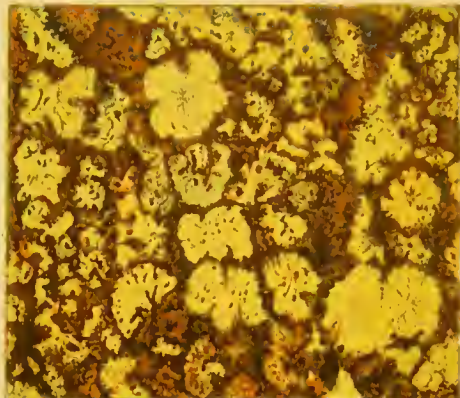
- 1.—Transverse section of the Brown Methil Coal.
- 2.—Longitudinal section of the same.
- 3.—Transverse section of the Black Methil Coal.
- 4.—Longitudinal section of the same.
- 5.—Transverse section of the Lesmahagow Cannel Coal.
- 6.—Longitudinal section of the same.

PLATE III.

- 1.—A section showing the Mineral and Coal in juxtaposition; magnified 3 diameters.
- 2.—Representations of the comparative sizes of the transverse sections of the brown elongated cells from various Coals, drawn by means of the camera lucida, by Dr. Adams, 70 diameters.
- 3.—Chippings of Newcastle Coal, showing dotted woody tissue.
- 4.—Ash of common domestic Coal, exhibiting the remains of a transverse section of wood.
- 5.—A longitudinal section of Coal from Loehgelly, showing its identity with a similar section of wood, from a drawing in the possession of Dr. Adams.
- 6.—Ash of Coal, exhibiting portions of siliceous cuticle and other fragments of vegetable tissue foreign to the coal.
- 7.—Powder of Breadisholme Coal, from a drawing by Dr. Adams.



$\times 130$



2

x 130



4

8.52

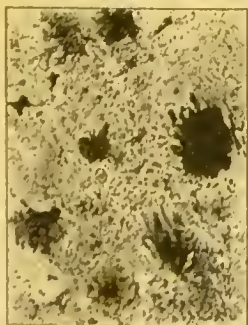


5

 $\times 7.5$ 

七

* 2011

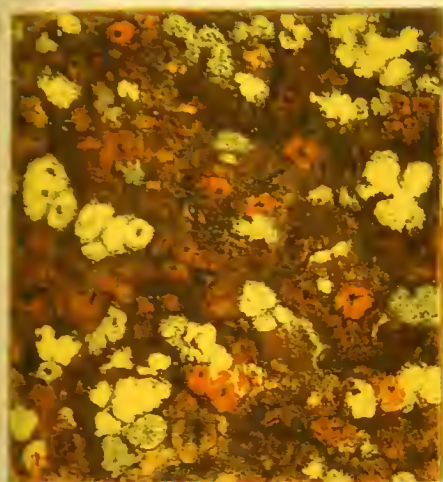


820x

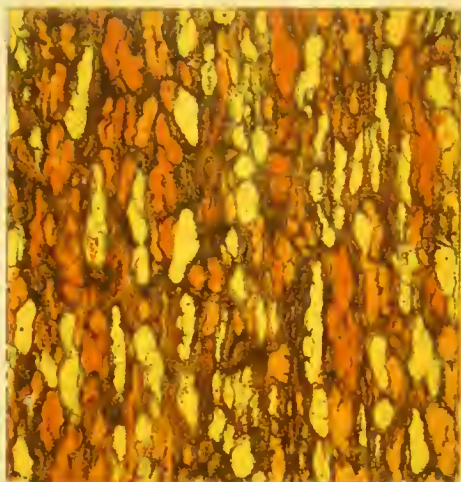


3

86



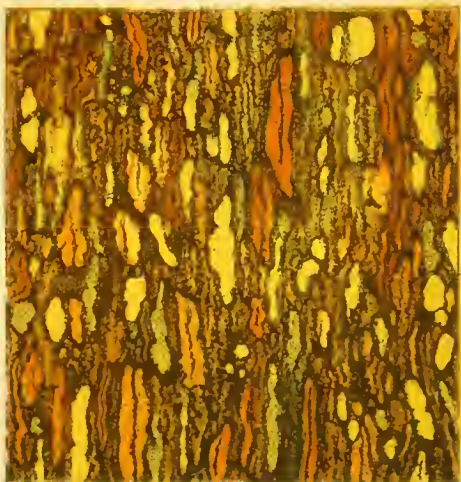
1



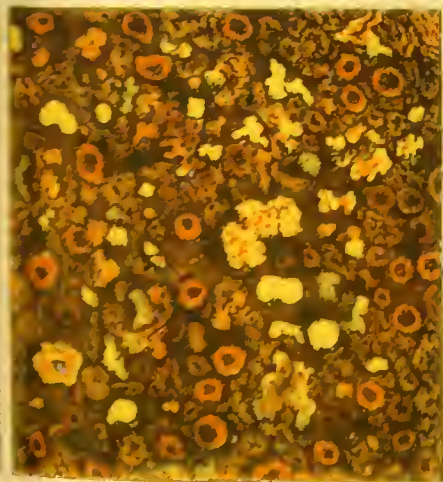
2



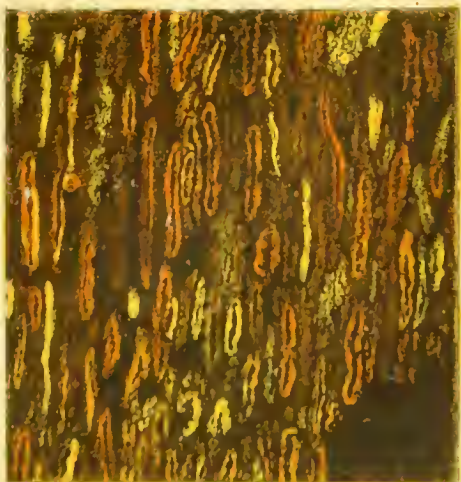
3



4

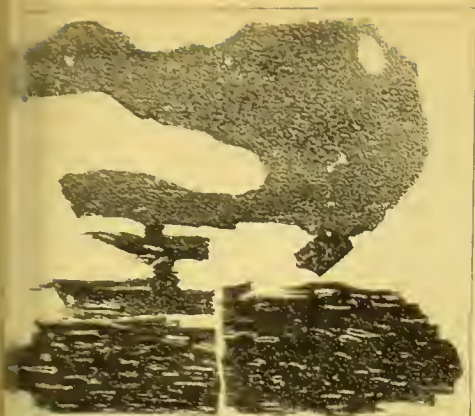


5



6

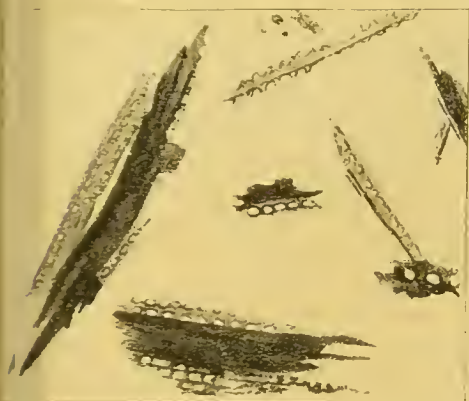
Scale 100 μ m



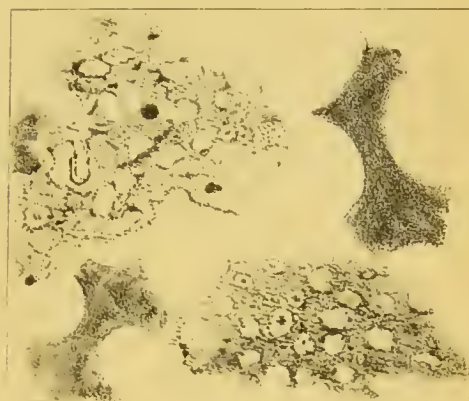
1 x 3



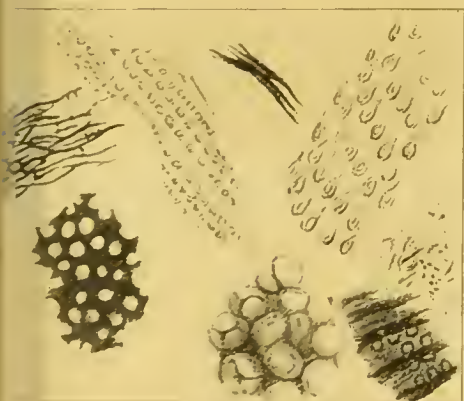
2 x 70



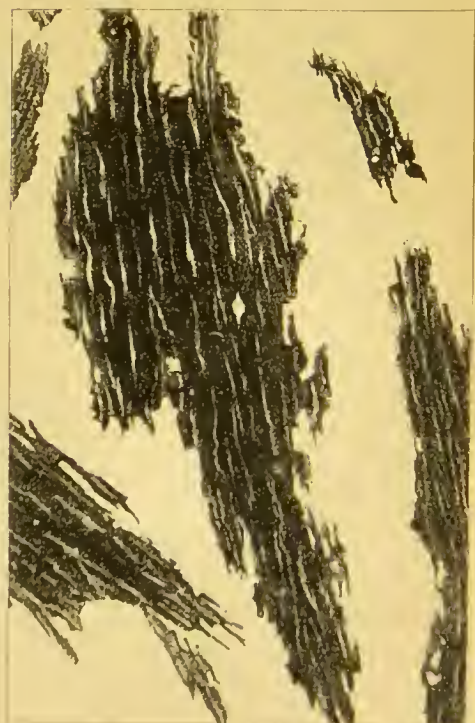
3 x 100



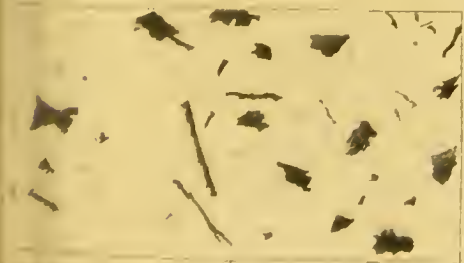
4 x 200



5 x 80



6 x 170



7 x 150

